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Genetics of a Dwarf Mutant in Groundnut

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Summary. A spontaneous dwarf mutant of groundnut variety, Kopergaon-3, showed differential expression for plant height and secondary branching characters in the reciprocal F_1 populations. These differences were assumed to be due to the interaction of nuclear and cytoplasmic factors which mutated with dwarfness.

Segregation for dwarfness in the F_2 and F_3 generations confirmed the monogenic inheritance. The mutant expression was, therefore, controlled by a pair of recessive factors designated $d^v d^v$, indicating dwarfism in the Valencia group.

Introduction

Dwarf phenotypes which are genetically controlled have played a prominent role in the evolution of high-yielding varieties in cereals and other crops (Chandler, 1968; Reitz and Salmon, 1968; Down and Andersen, 1956). Such phenotypes in the groundnut (*Arachis hypogaea* L., 2n = 40) were mostly sterile and their contribution to yield is not properly understood (Hayes, 1933; Patel et al. 1936; Hull, 1937; Seshadri and Seshu, 1956; Patil, 1966; Ashri, 1968; Coffelt and Hammons, 1972). However, Shchori and Ashri (1970) reported some induced fertile dwarfs in the *Valencia* group which showed simple inheritance.

A spontaneous mutant known as "Gujrat Dwarf" was obtained in a popular groundnut variety, Kopergaon-3, belonging to the Valencia group (Gopani and Vaishnani, 1970). Genetic studies on the dwarf character of the mutant indicated the occurrence of simultaneous mutations of nuclear and cytoplasmic factors influencing plant height and branching. Interaction of nuclear and cytoplasmic factors is suggested and the segregation pattern is described.

Materials and Methods

Seeds of "Gujrat Dwarf" were obtained in 1970 from the University of Agricultural Sciences, Dharwar, where it was being tested for yield potential in the All India Coordinated Project. The dwarf mutant was crossed with Kopergaon-3 (K-3), Spanish Improved (SP), Trombay Groundnut (TG) varieties viz., 1, 3, 6, 8 and 9 (Patil and Thakare, 1969; Patil, 1973) and a tall mutant (Patil, 1966), using the modified crossing technique (Patil, 1971). In addition, K-3 was crossed with SP and three TG-varieties.

Ten F_1 plants from each cross were grown in 1972 together with the parents. Plant height and number of branches at maturity were recorded and the results are summarised in Tables 1 and 2.

A limited number of F_2 progenies was grown during June-September, 1973. The population was scored for plant height and number of branches. The data on the frequency of plants according to their height and morphological appearance are summarised in Table 3. Normal and dwarf plants in F_2 were easily distinguishable in the field. However, both the phenotypic classes in the crosses with SP and TG varieties showed plant height variations within the classes which are not considered in the present discussion. Genotypic segregation for dwarfness was studied after growing the F_3 generation during 1974 (Table 4). The data were statistically analysed and the chi-square values are given in the tables.

Results and Discussions

Distinguishing characters of the dwarf mutant:

The dwarf mutant had a distinct phenotype with slightly smaller leaflets than K-3 (Fig. 1). It was easily distinguishable from normal plants four to five weeks after sowing. The delay in the expression of dwarfness was due to normal growth (2.5 cm/internode) of the basal four to five internodes and shortening of the subsequent internodes (0.5 cm/internode) on the stem. There was no difference in number of internodes between the mutant and other varieties. For mean height (Table 2), the mutant showed a seventy percent reduction compared with the parent. The X-ray induced tall mutant (Patil 1966), in contrast, had a 30 percent increase in height. The plant heights for K-3, SP, TG-1, 3, 6, 8 and 9 were generally

Table 1. F_1 plant height and branching character in the crosses with K-3

Cross	Plant height (cm)	Number of branches primary + secondary
d^v × K-3	82 ± 3.7	5 + 1
K-3xd^v	78 ± 3.2	5 + 0
K-3 × TG-1	120 ± 3.6	12 + 20
TG-1 × K-3	114 ± 4.6	12 + 21
K-3 × SP	106 ± 2.9	6 + 10
SP × K-3	108 ± 3.7	6 + 9
K-3 × TG-6	108 ± 4.6	6 + 10
TG-6 × K-3	110 ± 3.4	7 + 10
K3 × TG-8	111 ± 4.5	5 + 4
TG-8 × K-3	115 ± 5.6	5 + 5

d^v - dwarf mutant.

Table 2. Reciprocal differences in the crosses of dwarf mutant

Cultures	Parent		F_1 (♀ dwarf)		F_1 (♂ dwarf)	
	Height (cm)	No. branches P + S	Height (cm)	No. branches P + S	Height (cm)	No. branches P + S
Dwarf	24 ± 1.9	6 + 1	-	-	-	-
K-3	85 ± 3.1	5 + 0	81 ± 3.7	5 + 1	84 ± 3.2	5 + 0
SP	79 ± 2.5	6 + 7	80 ± 2.6	5 + 9	110 ± 1.6	5 + 1
TG-3	80 ± 2.3	6 + 8	77 ± 3.9	5 + 6	114 ± 2.4	5 + 1
TG-6	75 ± 2.6	6 + 6	81 ± 2.3	6 + 8	111 ± 2.3	5 + 1
TG-8	74 ± 2.1	5 + 3	78 ± 1.6	5 + 2	113 ± 4.9	4 + 0
TG-9	75 ± 3.4	5 + 4	84 ± 3.4	6 + 3	115 ± 2.5	6 + 1
Tall	107 ± 1.1	6 + 8	105 ± 1.5	7 + 14	122 ± 3.9	6 + 10
TG-1	80 ± 2.8	11 + 18	-	-	-	-

P = Primary: S = Secondary

Table 3. Segregation of dwarf in F_2 generation

Cross	F_1 progenies	F_2 segregation				χ^2 (3:1)	p value
		Normal		Dwarf			
		(50 cm)	(50-35 cm)	Parent	Extreme		
d^v x K-3	2	50	0	20	0	0.476	0.25-0.50
K-3 x d^v	2	56	0	26	0	1.966	0.10-0.25
d^v x Tall	2	77	5	20	1	1.068	0.25-0.50
Tall x d^v	2	170	8	45	1	2.380	0.10-0.25
d^v x SP	2	46	14	19	3	1.462	0.10-0.25
SP x d^v	2	40	8	11	1	0.800	0.25-0.50
d^v x TG-3	3	49	20	19	2	0.133	0.50-0.75
TG-3 x d^v	3	40	16	11	2	1.396	0.10-0.25
d^v x TG-6	3	36	21	15	0	0.700	0.25-0.50
TG-6 x d^v	3	61	17	27	2	0.252	0.50-0.75
d^v x TG-8	3	31	11	14	4	0.800	0.25-0.50
TG- 8 x d^v	3	43	8	22	3	2.525	0.10-0.25
d^v x TG-9	1	19	8	9	2	0.081	0.75-0.90
TG-9 x d^v	3	68	21	25	3	0.071	0.75-0.90
Pooled	34	786	157	282	24		
		943		306		0.167	0.50-0.75

Fig. 1. Left Spanish Improved; middle Kopergaon-3 and right dwarf

similar. The K-3 and dwarf differed from the others in not having secondary branches (n + 2). The pods and kernels of the dwarf were not distinguishable from those of K-3. Both had more 3-seeded pods and red kernels, while the others had more 2-seeded pods and rose kernels.

Reciprocal differences in F_1 expression:

The F_1 populations from reciprocal crosses of K-3, excluding that with the dwarf, showed increased plant height, which varied from 106 to 120 cm (Table 1), compared with 74-85 cm for the parents (Table 2). The expression of increased height in F_1, therefore, suggested overdominance for this character. In the reciprocal crosses between K-3 and the dwarf, however, the F_1 height was similar to that of the superior parent, indicating the dominance of K-3 plant height. This was expected since the dwarf was isolated from K-3.

Table 4. Genotypic segregation from F_3 generation

Crosses	Dominant homozygotes	Heterozygotes (normal/dwarf)	Recessive homozygotes	χ^2 (1:2:1)	p value
d^v x K-3	7	17 (823/296)	9	0.272	0.75-0.90
K-3 x d^v	20	32 (1586/470)	20	0.844	0.50-0.75
d^v x Tall	25	57 (1752/596)	20	1.900	0.25-0.50
Tall x d^v	55	125 (2496/812)	45	3.269	0.10-0.25
d^v x SP	20	39 (1818/570)	22	0.163	0.25-0.50
SP x d^v	14	20 (1022/385)	12	0.955	0.50-0.75
d^v x TG-3	32	37 (1869/591)	19	6.067	0.05-0.025
TG-3 x d^v	23	33 (1825/563)	14	2.540	0.25-0.50
d^v x TG-6	15	24 (1110/390)	12	0.529	0.75-0.90
TG-6 x d^v	18	35 (1550/541)	21	0.154	0.90-0.95
d^v x TG-8	9	32 (971/337)	17	4.113	0.10-0.25
TG-8 x d^v	24	36 (1167/426)	20	1.200	0.50-0.75
d^v x TG-9	10	15 (629/196)	7	0.687	0.50-0.75
TG-9 x d^v	4	20 (940/282)	6	3.599	0.10-0.25
Pooled	276	520 (19558/6455)	244	1.969	0.25-0.50

All the other crosses of the dwarf mutant exhibited reciprocal differences in the F_1 plant height (Fig. 2 a and b). Similar reciprocal differences for growth habit were observed by Ashri (1964). Significant increases in the height of F_1 plants resembling those of K-3 crosses were expressed only when the dwarf was the male parent (Table 2). On the other hand, when the mutant was female parent, the F_1 height was similar to that of the superior parent. The expression of overdominance when the mutant was male parent, and of dominance when female parent, suggested the influence of some cytoplasmic factor of the dwarf. The suppression of overdominance by the mutant cytoplasm demonstrated a probable mutation of cytoplasmic factor.

The presence of secondary branches in the F_1 plants of crosses with K-3 (Table 1) showed that the n+2 branching character (Gregory et al., 1951) was controlled by dominant factors. The absence of this character in K-3 and its mutant was due to recessive gene (s). Accordingly, n + 2 branching in F_1 plants was expected also in the crosses with the dwarf mutant. However, this character was absent in the F_1 plants resulting from the crosses with the dwarf as pollen parent (Table 2).

The suppression of dominant effect in the F_1 might be caused by the inhibitory action of gene(s) contributed by the pollen of the dwarf, so the expression of n + 2 branching of F_1 plants in the crosses of ♀ dwarf × SP types was abnormal. This was probably due to inactivation of the inhibitor in the mutant cytoplasm (Ashri, 1964; 1968).

The results on plant height and branching type obtained from the F_1 generation thus suggest that, in addition to a mutation for plant height, the dwarf might be carrying other mutations including those in the cytoplasm.

Genetic segregations for plant height:

Segregation studies in the F_2 and F_3 generations confirmed the recessive expression of dwarfness. The pattern of segregation was similar in all the reciprocal crosses and showed good fit to the monohybrid ratio (Table 3). Therefore, the occurrence of dwarf mutation in K-3 might be caused by a recessive mutation of a ma-

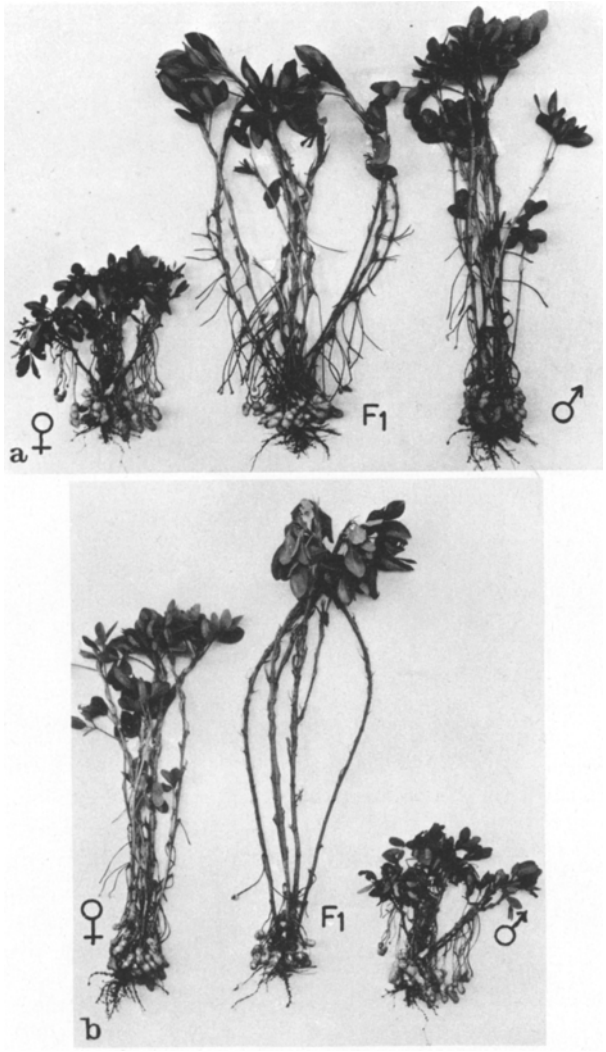

Fig. 2. Reciprocal differences in F_1 (a) dwarf as female (b) dwarf as male

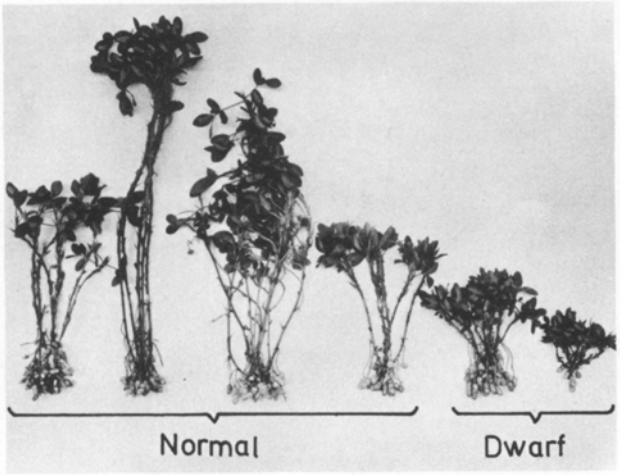

Fig. 3. Variability in F_2, left four plants from normal and remaining from dwarf class

jor gene, controlling plant height. It is interesting to note the presence of variability (Fig. 3) in both the normal and dwarf phenotypic classes in all the crosses except those with the parent variety, K-3. The occurrence of extremely dwarf plants, measuring less than 10 cm as compared with 24 cm in the dwarf parent, suggested that there were either modifiers or more than one gene influencing the plant height character.

Genotypic segregation of the dwarf showed 276 dominant homozygotes, 520 heterozygotes and 244 dwarf progenies. This segregation had an excellent fit with the expected ratio of 1:2:1 (Table 4) based on monohybrid segregation. The heterozygous progenies had 19558 normal plants and 6455 dwarf plants in the F_3 which further confirmed the monohybrid segregation. Therefore, dwarfness was controlled by a pair of recessive factors which may be genetically designated as $d^v d^v$, suggesting the dwarfness in the Valencia subgroup.

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